

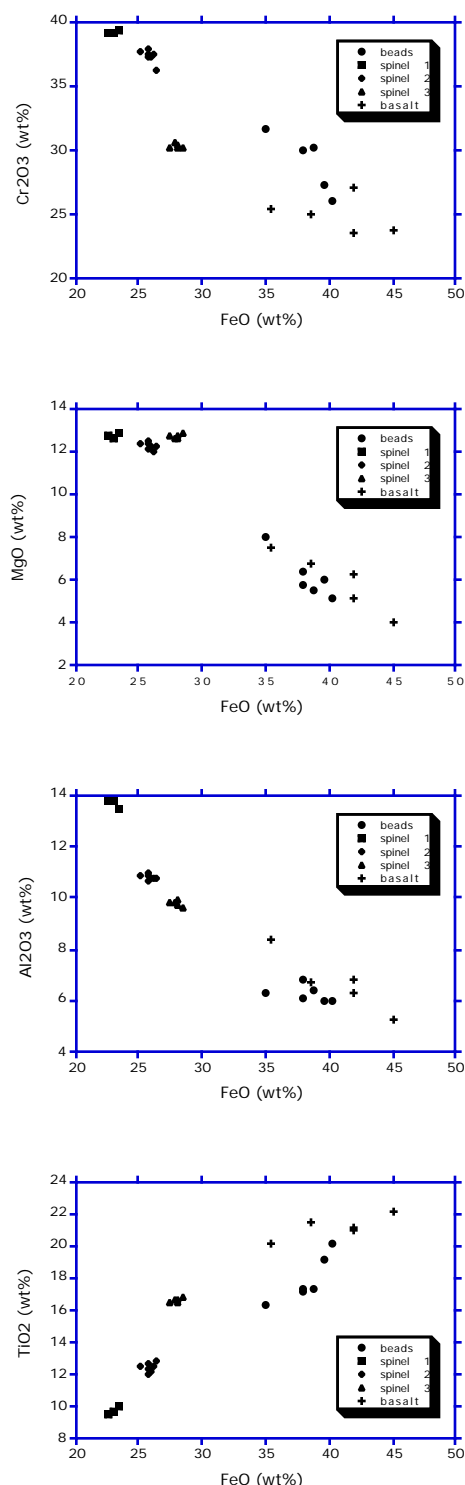
**OXIDATION STATE OF THE A17 ORANGE GLASS SOURCE AS INFERRED FROM INCLUSIONS IN OLIVINE PHENOCRYSTS.** M.J. Rutherford and C.M. Weitz, Geology Department, Box 1846, Brown University, Providence RI 02912, e-mail macr@brown.edu.

**Introduction.** Metal spherules trapped in olivine phenocrysts of the A17 orange volcanic glass deposit have been analyzed and used to determine the oxidation history of the orange glass magma [1]. The orange glass samples used in this study are 74220 and the 74001/2 drill core which includes 26 thin sections over a length of 68 cm through the deposit. The olivine phenocrysts are equant, up to 1 mm across, and euhedral to fragmented in outline as described by Heiken et al., [2]. The crystals are compositionally homogenous (Fo81) except for some obvious feathery textured overgrowths on olivines in the black crystallized beads. The metal spherules totally enclosed in olivine phenocrysts are homogenous ( $\text{Fe}_{85}\text{Ni}_{14}\text{Co}_1$ ). Consideration of the Fe-Ni equilibrium between the olivines, the orange glass magma, and the metal grains makes it possible to calculate the  $f\text{O}_2$  of the magma at the time the olivines were growing at depth. This calculation [1] indicates an  $f\text{O}_2$  of -11.3 (IW-1.3) at 1320 °C, the liquidus T of the orange glass magma. A few equant (16-28  $\mu\text{m}$ ) Cr-rich spinels were also entrapped in the olivine phenocrysts of 74001/2; three were found in one set of core samples and analyzed. The composition of the olivine coexisting with Cr-spinel and melt provides a separate estimate of the orange magma  $f\text{O}_2$  which can be compared to that calculated from the Fe-Ni distribution between melt and metal.

The effects of  $f\text{O}_2$ , T, and melt composition on the Cr content of coexisting olivine  $\pm$  spinel and melt have also been the subject of several experimental studies [3,4,5,6]. Almost all experimental studies show a pronounced increase in the distribution of Cr between olivine and coexisting melt with decreasing  $f\text{O}_2$  [4,5,6]. This decrease is generally attributed to an increase in the  $\text{Cr}^{2+}$  in the melt with decreasing  $f\text{O}_2$  which occurs in the vicinity of the IW oxygen buffer. Among these experimental studies, the work of Usselman and Lofgren (5) is most applicable to orange glass magma petrogenesis because they used a high-Ti mare basalt composition (74275) and it was used in this study.

**Data.** The spinels in 74001/2 and 74220 range from the few Cr-rich crystals trapped in olivine to chromian ulvospinel which is common in the crystallized black beads of the same samples (Fig.1). The Cr-ulvospinel in the black 74220 and 74001/2 lithology are compositionally similar to ulvospinel.

**Fig. 1.** Plot of the spinel compositions (FeO vs X) in the A17 orange glass magma: spinels 1-3 are traverses for those enclosed in olivine; beads = those in the black beads; and basalt = spinels in hi-TiO<sub>2</sub> mare basalts [7,8].



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found in high-TiO<sub>2</sub> mare basalts. However, with the possible exception of titanian chromites found in 74275, those found trapped in 74001/2 olivines are much more Mg, Al, and Cr rich and lower in Fe and Ti (Fig.1) than anything found in mare basalts.

The olivine phenocrysts in the 74001/2 samples cluster at  $0.36 \pm 0.04$  wt% Cr<sub>2</sub>O<sub>3</sub> (2460 $\pm$ 200 ppm Cr) for the Mg-rich (Fo<sub>81-82</sub>) olivines, but there is a small population of phenocrysts with significantly lower Cr<sub>2</sub>O<sub>3</sub>. Plotted in Fig. 2 along with the Usselman and Lofgren data for high-TiO<sub>2</sub> mare basalt experiments, the cluster of olivine compositions indicates a D<sub>Cr</sub> (olv/melt) for the orange glass of 0.54. It was also noted that the decrease in Cr<sub>2</sub>O<sub>3</sub> in the olivine phenocrysts is accompanied by a corresponding decrease in CaO from 0.3 to 0.15 wt%. The smaller olivine crystals which occur primarily in the black bead of 74001/2, define a trend of decreasing Cr<sub>2</sub>O<sub>3</sub> with decreasing forsterite in the olivine.

**Discussion.** The cluster in olivine Cr compositions at 0.36 wt% Cr<sub>2</sub>O<sub>3</sub> when compared to the Usselman and Lofgren experimental data indicates an fO<sub>2</sub> equal to or slightly lower than IW-1.0. This compares well with the estimate of IW-1.3 for the same orange glass magma at depth based on Fe and Ni distribution between the melt and the metal grains trapped in olivine phenocrysts [1]. Type II metal grains are in the outer rims of olivine or in glass. The metal-melt data for these metal grains indicates that the orange glass magma underwent an oxidation during and after the final stage of olivine phenocryst growth. One possible explanation for the trend of olivine compositions to lower Cr<sub>2</sub>O<sub>3</sub> is that these lower-Cr olivines were crystallized at successively later stages of this oxidation. The accompanying decrease in CaO

could be a compensating change in the olivine driven by the oxidation state changes in the magma. Ni contents of the olivines should demonstrate this oxidation, but the data are not definitive. Alternatively, the lower Cr<sub>2</sub>O<sub>3</sub> accompanying decreases in CaO in olivines of essentially constant forsterite composition may reflect growth rate changes during olivine phenocryst growth. The trend of Cr<sub>2</sub>O<sub>3</sub> decrease with decreases in Fo in the black lithology olivines (Fig. 2) is attributed to an oxidation relative to earlier olivine phenocryst growth conditions, because there is the independent evidence from the metal compositions that an oxidation was taking place during the fractionation that accompanied crystallization of the black beads.

**Conclusions:** (1) The inclusions in orange glass olivine phenocrysts indicates that three phases, Fe-Ni metal, Cr-spinel, and Fo<sub>82</sub> olivine, were crystallizing simultaneously in this magma prior to its eruption. (2) Both the metal-melt equilibria and the Cr content of olivine (+spinel) indicate a pre-eruption fO<sub>2</sub> of IW-1.3 for the pre-eruption magma. (3) Late-in-the-eruption oxidation of the magma indicated by more Ni-rich metal is also reflected in the Cr in the olivines.

**References:** [1] Weitz et al., 1997, G.C.A. in press, [2] Heiken G et al., 1974, G.C.A. 38, 1703-1718; [3] Akella et al., 1996, PLPSC 7th, p 1179-1194; [4] Huebner et al., 1996, PLPSC 7th, p.1195-1220; [6] Schreiber, HD, and Haskin LA, 1976, PLPSC 7th, p 1221-1259; [7] Usselman, TM, and Lofgren, GE, 1976, PLPSC 7th, p.1345-1363.

**Fig 2.** Cr<sub>2</sub>O<sub>3</sub> vs fosterite in olivines of the A17 orange glass magma. The two bands indicate the effect of fO<sub>2</sub> on olivine composition in a primitive Hi-TiO<sub>2</sub> mare basalt magma from the experiments of [5].

